

Personal Views on Taxonomy

BY

FRANZ ALFRED SCHILDER

University of Halle, German Democratic Republic

INTRODUCTION

THE EDITOR OF THE VELIGER has asked me to explain my personal views on specific and intraspecific taxonomy in cowries so that these principles might be discussed by students of other groups of mollusks.

I have discussed my views in several previous papers, chiefly in SCHILDER 1941 (p. 59), 1952 (pp. 13 - 14), 1960 (pp. 8 - 10), and 1963 (pp. 106 - 109). Nevertheless, I am delighted to attend the Editor's suggestion, as these papers are written, partly, in German, and, partly, treat special problems in cowries which are of no interest to other malacologists; besides, more recent studies in cowries have shown that the number of distinguished taxa should be augmented, for the ways of intraspecific differentiation are far more complicated than one should believe at first glance.

Therefore I shall try to explain the taxonomic problems in the following paragraphs.

Each problem and my personal suggestion to solve it will be illustrated by examples chosen among the living and fossil cowries to which I have devoted all my studies since 1920, with short interruptions only.

OFFICIAL NOMENCLATURE

The International Rules of Zoological Nomenclature, established in 1905 and emended in 1958 by the fifteenth International Zoological Congress in London, prescribe to designate the scientific name of each animal by at least two Latin or latinized words, viz. the generic and the specific name.

Thus the scientific nomenclature of the lower taxa is formally binary, i. e. composed of two names.

However, the rules admit the optional intercalation of two further taxa, viz. the subgenus (to be inserted, in parentheses, between the genus and the species name) and the subspecies (which follows the specific name).

Thus the scientific nomenclature of the lower taxa virtually becomes quaternary, i. e. composed of four names: genus - (subgenus) - species - subspecies; the subspecific name must not be separated by any sign or symbol from the specific name.

This method to classify natural history specimens was established by LINNAEUS in 1757 for plants and in 1758 for animals; however, LINNAEUS used subgeneric and subspecific names very rarely so that his nomenclature was practically binary.

LINNAEUS united all adult cowries in one genus, *Cypraea*, and he enumerated all living kinds known to him as different species, thereby separating specifically some juvenile stages (e. g. *vanelli* and *fragilis*) from the adult ones (*lynx* and *arabica*, respectively) and even worn specimens (e. g. *amethystea* and *lota*) from fresh ones (*arabica* and *spurca*, respectively). In the butterfly genus *Papilio* he used *Troides* in a subgeneric sense, and he named the chief races of man by subspecific terms.

TAXONOMY

Surely this venerable principle of binary or quaternary nomenclature is sufficient for many purposes, especially if one considers the living animals as existing units, almost as LINNAEUS did in believing in a supernatural spontaneous creation of species.

Therefore I have no objection against calling all cowries by the generic name *Cypraea* and by the name of the species in faunistic lists, in dealer's catalogs, etc.; in such papers the species may even be enumerated in alphabetical order, which is accidental, caused by the fancy of the name's author and conceals the evident affinity of species, but facilitates the finding of the name by the non-specialist.

This principle fails, however, if the specialist intends to demonstrate his opinion about the phylogeny of the various taxa by investigating the gradual evolution of taxonomical units, particularly if he includes the fossil connecting links and their differentiation by steps to the living units.

So, for instance, the rich material of Neogene fossils from Florida has shown that the classification of the specimens connecting the Miocene *Siphocypraea (Akleistostoma) carolinensis* (CONRAD) and the Pliocene *S. (Siphocypraea) problematica* (HEILPRIN) is rather arbitrary (SCHILDER, 1965 a). Therefore the specialist should be allowed to intercalate several stages of taxa between the officially admitted ones, so that he may clearly show the supposed relation of various extinct and living taxa.

FAMILIES AND GENERA

On the level of the family and genus the subdivisions subfamily and subgenus are official; additionally, the term *tribus* for different units within the subfamily has been admitted; the subgenus, however, is the lowest admitted degree on the generic level.

Many authors, however, considered it useful to introduce a further taxon on the generic level, which is inferior to the subgenus: THIELE (1929), for instance, called it *sectio* and was followed by other writers on marine mollusks, although this term sometimes caused confusion (STOHLER, 1965).

I consider it positively necessary to establish a taxon subordinate to subfamily and subgenus (S), especially in monographs and lists which claim to illustrate the phylogenetic affinity of extinct and living animals: in earlier papers I proposed to call these taxa *infracolony* and *infracolony* (I) respectively.

The relative value of a taxon is recognizable more easily if it is designated by the same prefix on the family, genus, and species level: thus the prefix *sub-* indicates the first degree below the prefix-less term (subfamily, subgenus, subspecies), and the prefix *infra-* indicates the second degree below the prefixless term (*infracolony*, *infracolony*, *infracolony*). This analogous terminology has not been invented by myself, but adapted to the use in the highest taxa (class, *ordo*) of fossil and living mammals by SIMPSON, 1945.

EVOLUTION OF SPECIES

There are two ways of evolution of species:

The usual *allopatric* way evidently consists in isolation of populations and selection of mutations by changes of the environment.

This relatively slow way results in gradual changing of one species into another during geological epochs. In geographically expanding species there arise *allopatric* units which become gradually more fixed genetically and more distinct morphologically, passing the stages *infracolony*, *cline*, *subspecies*, *prospecies*, and at last true species (see below).

A second, rare, way consists in the *sympatric* development of *schizospecies*, i. e. of species living together in a restricted area "caused by sudden change of sexual affinity" (BUDDENBROCK; see SCHILDER 1952, pp. 19, 35).

Morphes (see below) may be stages of this way of specific differentiation. In cowries the South African *Cypraeovula* (including *Luponia*) and the South Australian *Notocypraea* possibly are *schizospecies*.

The usual *allopatric* way of evolution tends to develop

SUPERSPECIES

A *superspecies* comprises all species and lower taxa which replace each other geographically, ecologically, or stratigraphically (chronologically), and which are so closely allied that they evidently descended from one common ancestor. It is irrelevant whether its offspring remained on the subspecific level or now must be classified as several distinct species or even genera (SCHILDER 1952, p. 11).

The term *superspecies* (SCHILDER, 1952, p. 2) coincides with the "Formenkreis" of KLEINSCHMIDT (1926) and comprises both the "Rassenkreis" and the "Artenkreis" of RENSCH (1929, p. 13); the "superspecies" of E. MAYR (1942, p. 169) is identical with the latter only.

In contrast to the other taxa, the unit *superspecies* does not bear a proper name, except if it coincides with an *infracolony*, etc.; it should be designated as *superspecies* by the name of the nomenclatorially oldest species included.

The *superspecies Erosaria miliaris* (GMELIN) contains nine or ten living and two or three fossil taxa (SCHILDER & SCHILDER, 1939, p. 225, figs. 7, 9; SCHILDER 1952, p. 110, fig. 83). The central species is *E. miliaris* (GMELIN) with its three *infracolony* *differens* SCHILDER in Malaysia, *miliaris* s. str. in East Asia, and *diversa* (KENYON) in Australia; the eastern *prospecies eburnea* (BARNES) in Melanesia and Queensland; the western *prospecies lamarcki* (GRAY) with two subspecies, viz. *redimita* (MELVILL) occurring from Malacca to Karachi and *lamarcki* s. str. in East Africa. The north western *E. turdus* (LAMARCK) must be included into this *superspecies* although it is well separable as a distinct species: for it can be morphologically derived from *lamarcki* and it replaces it in the Red Sea and in the Persian Gulf, only slightly overlapping its area of distribution; it should be split into the *infracolony turdus* s. str. in the southern Red Sea, *pardalina* (DUNKER) around the Sinai Peninsula, *winckworthi* SCHILDER & SCHILDER in the north east from Muscat to Karachi, and the dubious *zanzibarica* (SULLIOTI), said to come from Zanzibar. Besides, according to SCHILDER 1941 (p. 91) there is a hardly separable ancestor of *differens* in the Pleistocene of Java (named *effossa* SCHILDER), an antecessor of *miliaris* s. lat. in the Upper Pliocene of Java which possibly may be separated as a species, *pliotaphylaea* SCHILDER, and the possibly late Miocene *sabahensis* (COX) from North Borneo. The living *Erosaria erosa* (LINNAEUS) with its races and the *prospecies nebrites* (MELVILL) as well as some fossil ancestors constitute a different *superspecies*, as they occupy about the same regions in the Indopacific as those inhabited by the *superspecies miliaris*.

The *superspecies* concept is a very fruitful basis in taxonomy, and it has been widely used, especially in ornithology and entomology.

In my catalogue of fossil and living Cypraeacea (SCHILDER 1941) I have tried to arrange all distinguishable units in cowries according to this and the following principles.

SPECIES

According to the International Rules of Zoological Nomenclature the taxon *species* is the fundamental category in zoological classification. But though treating the name of species most precisely, the Rules avoid to define the qualities of a taxon necessary to justify its rank as a species.

In fact, it seems almost impossible to establish a clear definition of the taxon *species* which fits similar stages of evolution in all branches of animal life, especially if one includes the fossil ancestors of the living species also. One should consider that the concept of species is still influenced by the former belief in spontaneous creation, and it would become rather meaningless if we could discover the complete series of extinct predecessors of the present species.

Many scientists seem to have adopted the definition given by RENSCH (1929, p. 4; SCHILDER 1952, p. 11): a species comprises all specimens the natural or artificial cross breeding of which produces an unlimited sequence of fertile generations showing no signs of degeneration.

Thus the horse and the donkey are different species as their hybrids, the mule and the hinny, usually are sterile; whereas all living races of man constitute a single species as their hybrids produce unlimited generations of fertile descendants. But what about Neandertal man? And where are the limits of Trinil and Peking man? The joke: "Which man first knew that he was no longer an ape?" is of deep phylogenetical meaning, also for the species concept.

In marine mollusks, however, RENSCH's physiological definition of the taxon species is useless, as we never can breed a second generation of hybrids.

Even the occurrence of evident hybrids in border areas occupied by two allied species does not prove them to be races of a single species, as these specimens may be the first hybrid generation destined to expire without progeny (e. g. *Cypraea tigris* LINNAEUS and *C. pantherina* SOLANDER in Aden; see SCHILDER, 1962).

Therefore I provisionally replaced the physiological test by the following morphological test: "groups of similar shells should be treated as different species if they can be separated by at least one well recognizable character showing no intermediates even in extreme specimens" (SCHILDER 1960, p. 8). This definition refers only to adult, not pathologically deformed, shells with well preserved colors.

In cowries, differences of the animals can hardly be used as criteria since we do not know the limits of individual variation in the soft parts nor in the radula of the animal, and the animals of many taxonomically important species are entirely unknown. The definition concerning the shells, however, can be applied also to fossils.

The upper limit of the taxon *species* can easily be recognized: morphologically isolated units of specimens living mostly in relatively small areas and evidently being relics of groups of allied species which flourished in a much wider area in the geological past; such species mostly constitute different genera or subgenera which are monotypic to the student of Recent mollusks only, but polytypic to the paleontologist.

In living cowries such phylogenetically isolated relics are, for example, *Bernaya catei* SCHILDER, *Siphocypraea mus* (LINNAEUS), *Trona stercoraria* (LINNAEUS), *Propustularia surinamensis* (PERRY), *Umbilia armeniaca* (VERCO) (including *hesitata* IREDALE), etc.

There are many other living units of specimens which are so well separable from each other conchologically that no student will ever doubt that they must be classified as distinct species, even if their animals seem to show no differences.

Thus, the common *Lyncina vitellus* (LINNAEUS) and *L. carneola* (LINNAEUS) surely are different species, as their adult shells can be distinguished at first glance on the basis of several constant characters in color, while the structural differences are less obvious. But the radulae of both are practically identical, the very young ("oliviform") stages of shells are hardly distinguishable, as are fossil representatives destitute of color: in fact, the Pliocene *yokoyamai* SCHILDER, which was established as an extinct Japanese giant race of *carneola*, most probably belongs to *vitellus*.

INTRASPECIFIC TAXA

The lower limit of the taxon *species*, however, is rather uncertain, as it is often difficult to decide whether the gradual evolution has transgressed the verge of the unit formally called species or not.

So, for instance, many monographers (e. g. KIENER, REEVE, SOWERBY, ROBERTS, HIDALGO, ALLAN) have treated *Erosaria lamarcki* (GRAY), *Erosaria miliaris* (GMELIN), and *Erosaria eburnea* (BARNES) as well separable species (*eburnea* has been separated even generically as the monotypic *Albacypraea* STEADMAN & COTTON). Their general structure is rather similar, but the color differs in a constant way: *lamarcki* (East Africa to Malacca) and *miliaris* (Japan to Australia) are fulvous to brownish with white dorsal spots, the former has numerous chestnut spots on the margins which are always absent in the latter, while *eburnea* (Melanesia to Queensland) is pure white. Careful study, however, has disclosed very rare shells with connecting characters: the *inocellata* (= *miliaris*) figured by VERDCOURT (1962, figure 1) from Zanzibar could be interpreted as a pathological *lamarcki*, laterally suffused by white enamel (in fact, I possess a laterally almost unspotted *lamarcki* from Zanzibar), whereas I have received a rather juvenile *miliaris* from Wakayama prefecture, Japan (leg. P. Clover) which exhibits many pale brown spots on the columellar side, and a few spots on the labial margin also. In *eburnea* rare specimens are white with still more pure white

spots in some parts of the dorsum: they may be interpreted as hybrids in areas where *eburnea* and *miliaris* overlap (Queensland), but they evidently are atavistic in regions where *eburnea* only occurs (Fiji).

It is difficult to decide whether such closely allied taxa should be separated as distinct species or united as subspecies of a single species: the International Rules of Zoological Nomenclature admit these two alternatives only. The result is that there will be always not only different views of different writers, but also different views of the same writer in different papers, according to the progress of knowledge and the special purpose of the paper (see above).

Recently DONOHUE (1965) has deplored the fact that many cowrie species treated as such in one paper have been reduced to subspecific rank in another paper or even suppressed as synonyms in a third paper: the particulars show the inevitability of frequent changes if only two taxa, species and subspecies, are admitted.

INTRASPECIFIC TAXA WHICH *MUST* BE NAMED

The general taxon *subspecies* adopted by the International Rules of Zoological Nomenclature has not been defined substantially by them.

Literally the term 'subspecies' comprises all named taxa lower ("sub") than the species so that all names which are not absolute synonyms could be regarded as of subspecific rank. However, it became the general custom to exclude named individual and accidental "varieties," and to reserve the term 'subspecies' to the different stages of evolution which did not yet reach the level of a species.

Therefore zoologists usually restrict the taxon *subspecies* to morphologically discernible, genetically rather uniform, and geographically or stratigraphically continuous "races" which replace each other in different areas or strata so that their totality composes the next higher taxon, the species.

This definition excludes all individual "varieties" as single mutants, extreme "aberrations" in any direction of variation, sexual, seasonal, or ontogenetic "formae," pathological "monstrosities" and artifacts. But the status of ecological modifications and of aberrant, locally restricted populations caused by selection of mutants remains uncertain.

Even in adopting this restriction the official taxon *subspecies* contains several very different stages of evolution so that it seems advisable to split it at least in four degrees.

Formally these degrees must be treated as coordinate subspecies according to the International Rules of Zoological Nomenclature;

but in papers discussing the exact value of each unit the respective letters (see below) should be put, in parentheses, before the subspecific names, as I have done in my zoogeographical paper on cowries (SCHILDER, 1965).

The four intraspecific stages of evolution, enumerated from the uppermost to the lowermost, are as follows:

(p) prospecies

Prospecies are taxa on the threshold between subspecies and real species: they are species *in statu nascendi*.

The term 'prospecies' was introduced in science by BIRULA in 1910 (SCHILDER 1952, p. 13); the term 'semispecies' (E. MAYR, LORKOVITCH) is a later synonym.

The taxon prospecies should be used in all cases of uncertainty whether a taxon has reached the degree of a true species, or not yet.

Then *Erosaria lamarcki*, *miliaris*, and *eburnea* (see above) evidently are prospecies of a single species, which must be named *miliaris* by law of priority, though *lamarcki* probably was the ancestral cowrie from which the other two prospecies have developed.

Authors generally should be permitted to use prospecific names either as specific ones or only as subspecies names, according to their momentary personal views and the purpose of their papers.

Then the changes deplored by DONOHUE (1965) would partly vanish or at least become legal; the frequent question of collectors, however, how many cowrie species exist, would become irrelevant.

(s) subspecies

Subspecies (in my narrow interpretation) are morphologically well distinguishable taxa which are widely distributed geographically or stratigraphically and replace each other in space or time; the border area in which two subspecies gradually pass into each other is a relatively narrow zone.

Erosaria miliaris (p) *lamarcki* has developed two geographical subspecies ("races"): the large, brown, mostly ocellated (s) *lamarcki* (s. str.) lives in East Africa, while the small, greenish fulvous, never ocellated (s) *redimita* (MELVILL) ranges from Karachi to Mauritius and Malacca; in Madagascar both subspecies meet, and in Port Reitz, Kenya, an intermediate population has been discovered (SCHILDER, SCHILDER & BENTON, 1962); the absence of purple ocellations in *redimita* recalls the still farther eastern *miliaris* (p) *miliaris*.

(c) cline

Clines differ from true subspecies by the far more gradual passing of adjacent taxa into each other, so that only specimens coming from opposite extremes of the inhab-

ited areas show typical characters, while the large area between these extremes contains populations of intermediates or of mixed extremes (HUXLEY, 1939).

Erosaria caputserpentis (LINNAEUS) exhibits usually white interstices of the teeth in the tropics; but along the coast of Queensland specimens with brown interstices increase in number so that in southern New South Wales the (c) *caputanguis* (PHILIPPI) predominates in which the brown color extends even across the base.

Clines often show remarkable parallelism in different parts of the world which tend to exhibit similar climatic conditions.

In *Erosaria caputserpentis* also another branch shows analogous tendencies in West Australia: the most extreme (c) *kenyonae* SCHILDER & SCHILDER occurs in South West Australia.

The extremes of such parallel clines in different regions are often hardly distinguishable from each other: therefore they should be classified as infraspecies (see below) of a single cline.

There is a parallelism in characters of aperture, dentition, etc. between the South African *Erosaria helvola* (c) *meridionalis* SCHILDER & SCHILDER and a very similar still unnamed infraspecies in South West Australia.

Certain tendencies in parallel or concentric variation of less important characters which can be observed in many species should not be neglected, but not named as clines though they have been caused by the same laws of evolution.

In many cowrie species one can observe that the average size in central populations is distinctly smaller than in peripheral populations (not only in northern and southern, but also in eastern and western regions); by naming these phylogenetically very interesting, but taxonomically less important clines the nomenclature would become too complicated.

The gradual development of characters in clines may rise to a chain ("Rassenkette" of SARASIN 1899) of higher taxa as far as to the species level, if it spreads over long distances.

In the superspecies *Erosaria miliaris* (GMELIN) there is a gradual decrease of brown pigment from the west (*turdus* and *lamarcki*) to the east (*eburnea*), whereas in *Luria isabella* (LINNAEUS) the blackish spots within the orange tips increase from East Africa (totally absent) to Hawaii and Mexico (very large and confluent) so that four taxa of subspecific to prospecific rank can be distinguished: (s) *isabella* (s. str.), (s) *lekalekana* (LADD), (s) *controversa* (GRAY) and (p) *mexicana* (STEARNS) (SCHILDER 1961).



(i) infraspecies

Infraspecies differ from true subspecies by the differences in morphological characters being still undeveloped so that they can be distinguished at most statistically by the means of populations with regard to the sums of slight differences.

Such "subraces" seem to exist in many common cowrie species distributed from East Africa to Polynesia, e. g. *Mauritia mauritiana* (LINNAEUS), *Cypraea tigris* LINNAEUS, etc. in which by statistical methods an Indian and a Pacific infraspecies seem to be distinguishable.

In species the distribution of which is discontinuous, one should suppose that at least statistical differences do exist, as during the long separation the genetic composition of populations must have become different. Even if no morphological differences could be discovered as yet, these disconnected parts should be named as infraspecies.

In *Erosaria poraria* (LINNAEUS) the Pacific "race" *scarabaeus* (BORY) is mostly distinguishable from the typical Indian *poraria*: they are separated by a broad gap in central Malaysia. In *Mauritia depressa* (GRAY) and in *Chelycypraea testudinaria* (LINNAEUS), however, real differences between the Pacific populations and the Indian representatives (*M. d. dispersa* SCHILDER & SCHILDER and *Ch. t. ingens* SCHILDER & SCHILDER) could not yet be discovered in a satisfying way, although they are separated by similar gaps. All should retain their infraspecific names.

The four intraspecific taxa discussed above are characterized by the areas of geographical or stratigraphical distribution of allied taxa, which exclude each other generally: these taxa are allopatric.

To these four allopatric taxa, the naming of which is obligatory according to the International Rules of Zoological Nomenclature, I add a fifth sympatric taxon, the

(m) morphé.

Morphes are sympatric units of very closely allied specimens which differ by some often unessential characters; these differences, however, are constant and intermediates are absent or rare, as morphes evidently are highly stable mutants.

The term 'morphé' introduced by HUXLEY (1955, p. 9) classically refers to the hereditary varieties of the European land snails of the genus *Cepaea* (SCHILDER & SCHILDER, 1953/57, where the morphé has been called 'conspecies'). In cowries it becomes illustrated by *Lyncina carneola* (LINNAEUS) and its morphé *titan* SCHILDER & SCHILDER (1962) which is restricted to the western border area of the Indopacific species: it differs by its enormous size in both sexes so that there are hardly any dubious intermediates, while the statistical differences in other characters of the shell and of the radula are small though mathematically

significant; though living in the same places with usual small *carneola* cross breeding seems not to occur, as no mating between the two morphes has been observed. On the eastern border area of *carneola*, especially in Hawaii, a similar giant morphe *leviathan* SCHILDER & SCHILDER seems to prefer different environments. The South African *Ovatipsa chinensis* (m) *tortirostris* (SOWERBY) seems to be a morphe tending to dwarfishness, reduction of teeth, and wide aperture (the last named character occurs in other South African cowries also) so that it appears pathological, but it lives in several localities alongside the typical *chinensis* (GMELIN) without intermediates.

The evolution of morphes may start by "ecotypes" (see below) and end in the sympatric so-called "sibling species," e. g. *Erronea erronea* and *E. ovum* (GMELIN) or in schizospecies.

INTRASPECIFIC TAXA WHICH CAN BE NAMED

There are two groups of variations which concern populations in restricted areas and are prominent by striking characters of many or all individuals:

(v) variatio

Varieties (in a narrow sense) are single populations restricted to small areas, all members of which exhibit a special character which will be rarely found in single specimens of other populations. Evidently the distinctive character has been caused by propagation of a genetical mutant within the only isolated population.

Palmadusta saulae (GASKOIN) ranges from Japan to New South Wales without being separable into distinct geographical races; its type locality is in Manila Bay; only 750 miles south of it, in the Siasi Islands, CATE (1960) discovered a population in which the dorsal blotch is rather reduced, and he named it subsp. *siasiensis*, but evidently the taxon 'variatio' better fits this population, as I have described an unnamed population from the Coral Sea in which the dorsal blotch is totally absent (SCHILDER, 1965 b).

By further research such varieties often may become infraspecies or aberrations (see below).

They will be raised to infraspecies if similar populations are found in a larger continuous area, but they will be degraded to aberrations if such populations are collected scattered between typical populations.

(a) aberratio

Aberrations are populations the members of which have been influenced by certain special conditions of their habitat; they will be found in scattered places with similar environments.

Such modifications are the large, slender, and light shells coming from calm waters contrasting to the smaller, broader, and heavier shells from the surf areas, as is the case in *Mauritia arabica* (LINNAEUS), *Erosaria erosa* (LINNAEUS), *Erronea caurica* (LINNAEUS), etc. In *Erosaria labrolineata* (GASKOIN) and in *Erronea erronea* (LINNAEUS) the differences between the populations coming from the Great Barrier Reef and from the mainland coast of Queensland may be explained in the same way.

Often the members of aberrations exhibit the peculiar characters in different degrees according to the intensity of influence of habitat and to the individual susceptibility.

The melanistic rostrate modification of *Mauritia eglantina* has been named *nigricans* CROSSE (= *niger* ROBERTS); in 1962, W. O. CERNOHORSKY collected it at Mondoure Outer Reef in New Caledonia, where about one sixth of the specimens showed at least tendencies to melanism and rostration, whereas this aberration was totally absent in adjacent localities. Most cowrie species become rostrate in several localities of New Caledonia, but sometimes also in remote places, as in Queensland and in Mauritius.

Some aberrations show tendencies to become morphes (see above).

In *Monetaria* we have distinguished several "ecotypes" (SCHILDER & SCHILDER 1937), i. e. morphologically very different aberrations which compose the populations in different percentages; mostly one ecotype is prevalent while others may be entirely absent. One could call them morphes if there were not so many intermediate specimens.

Other aberrations, however, could be regarded as pathological.

Many "suffused" aberrations are natural, e. g. *Erosaria miliaris* (GMELIN) which becomes suffused with a thin layer of white enamel starting from the white margins. But other suffused aberrations are evidently pathological, as the additional dorsal enamel (which is mostly greyish to greenish and conceals the usual markings) covers numerous particles of mud and other substances entered between the shell and the mantle.

In an earlier paper (SCHILDER & SCHILDER 1938, p. 122) we have proposed to characterize the aberrations by homonymous abbreviations replacing the names; established names could be added, but no new names should be introduced.

We proposed the terms *forma major*, *minor*, *oblonga*, *dilatata*, *rostrata*, *pellucida*, *pallida*, *saturata*, *confusa*, and *suffusa*, each abbreviated by three or four initial letters.

We add a third group the naming of which is optional: it concerns single specimens only:

(h) hybrida

Real hybrids between different prospecies or even species usually are rare in the animal kingdom.

In cowries hybrids between *Cypraea tigris* LINNAEUS and *C. pantherina* SOLANDER have been collected at the common border of their inhabited areas in Aden (SCHILDER, 1962). The reported hybrids between *Erosaria miliaris* (GMELIN) and (p) *eburnea* (BARNES) as well as between *Erronea erronea* (LINNAEUS) and *E. caurica* (LINNAEUS) are dubious.

INTRASPECIFIC TAXA WHICH *MUST NOT* BE NAMED

All other taxa do not deserve special names; if they have been established before, they should be treated as synonyms.

They are virtual synonyms; formal synonyms, however, arise only from replacing invalid homonyms by new names or by establishing several names on the same holotype or the same figure.

Such taxa should be comprised as

forma,

but I recommend to distinguish the following different kinds and to designate them by further letters in synonymic lists, etc.:

Three formae occur in sporadic individuals only:

(e) forma extrema

Rare single individuals exceeding the other specimens in size, shape, or color, usually represent extremes of aberrations only.

Such extremes unnecessarily have been named, chiefly in Mediterranean cowries: e.g. MONTEROSATO called the largest specimen of *Luria lurida* (LINNAEUS) known to him "var." *maxima* (the name is preoccupied).

(d) forma deformis

This category comprises all pathological monstrosities as sinistral shells, specimens grown in an abnormal way (e.g. with the spire much projecting) or showing unusual irregular markings; as well as all deformations caused by fractures of the shell healed by layers of enamel during the animal's life, or by adherent barnacles, etc. partially or completely covered by enamel.

The only known sinistral cowrie shell is a *Notocypraea declivis* (SOWERBY); a pathological abnormality in color is e.g. *Lyncina lynx* "var." *michaelis* (MELVILL); a barnacle-bearing *Lyncina vitellus* (LINNAEUS) figured by COX was named *distorta* by HIDALGO (nomen nudum) and IREDALE (valid name).



(f) forma falsa

This category refers to shells which have been altered, chiefly in color and texture, after the animal's death by natural influences or artificially by manipulations of man.

Cypraea lota LINNAEUS is a bleached *Erosaria spurca* (LINNAEUS), *C. ostergaardi* DALL is the subfossil representative of the *Erosaria* species the living representative of which has been described as *C. alleni* OSTERGAARD. *Cypraea amethystea* LINNAEUS is a *Mauritia histrio* (GMELIN) the dorsal upper layers of enamel of which have been removed by acid, and *M. eglantina* "var." *coutourieri* (VAYSSIÈRE) has become artificially zonate by using a hot instrument.

Three other formae are theoretically present in all individuals:

(♀ ♂) forma sexualis

The females and males are so different that they have received different names by authors not knowing that the differences are sexual only.

In cowries the sexual differences of shells and radulae are very slight so that they can be stated by statistics only; the sex of the holotypes of most established taxa is unknown.

(t) forma temporaria

Subsequent generations of adult animals differ according to their living in different seasons of the year.

The longlived cowries cannot exhibit such differences as frequently occur in butterflies, etc.

(j) forma juvenis

The stages of the individual growth differ not only in size, but also in other striking characters.

In the growing cowrie the size, shape, structure, and color of the shell become very different so that many not yet adult stages have been named as distinct species by early writers. In the "Prodrome" (SCHILDER & SCHILDER 1938, p. 123) we have distinguished seven stages: *pulla*, *oliviformis*, *perjuvenis*; *juvenis*, *junior*, *subjunior*, *adulta*; in quoting the names given to them in various species one could combine the three first ones as (jj), the two following as (j), while the subjunior shells look rather like the adult ones.

SUMMARY

This minute discernment of taxa based on evolutionary classification appears rather exaggerated, but nature itself is not simple.

Virtually the proposed classification does not affect the present International Rules of Zoological Nomenclature which I think must be strictly observed with regard to

the rules of priority and homonymy of names: for the obligatory binary or quaternary nomenclature does not become violated by the optional intercalation of the proposed letters (in parentheses) indicating the evolutionary status of the taxon.

There are three ways to quote discernible taxa: with or without naming the intermediate taxa, or by suppressing the lower ones.

1. By mentioning the intermediate taxa the total name often becomes at least sexternary so that it is unmanageable and disagrees with the International Rules of Zoological Nomenclature; but it clearly shows the relation of the lowermost taxon to the higher ones.

So, for instance, the long term *Erosaria* [(S) *Erosaria* (I) *Ravitrona*] *cernica* (p) *tomlini* (s) *ogasawarensis* (i) *marielae* (CATE) shows that a specimen identified as *marielae* does not belong to (S) *Paulonaria*, (I) *Erosaria*, (p) *cernica*, (s) *tomlini*, and (i) *ogasawarensis* nor (i) *maturata*.

2. By suppressing the intermediate taxa the nomenclature becomes quaternary as it is demanded by the Rules, but the taxonomic hierarchy becomes concealed.

Then the last named example runs as follows: *Erosaria* [(I) *Ravitrona*] *cernica* (i) *marielae* (CATE); the essential species and subspecies cannot be recognized by this term.

3. By suppressing the lowermost taxa: this method should be avoided as it does not agree with the present status of distinctive taxonomy elucidating the evolution of animals.

The term *Erosaria* [(S) *Erosaria*] *cernica* (p) *tomlini* SCHILDER annihilates the great effort of specialists to distinguish subtle taxonomic differences between populations and specimens.

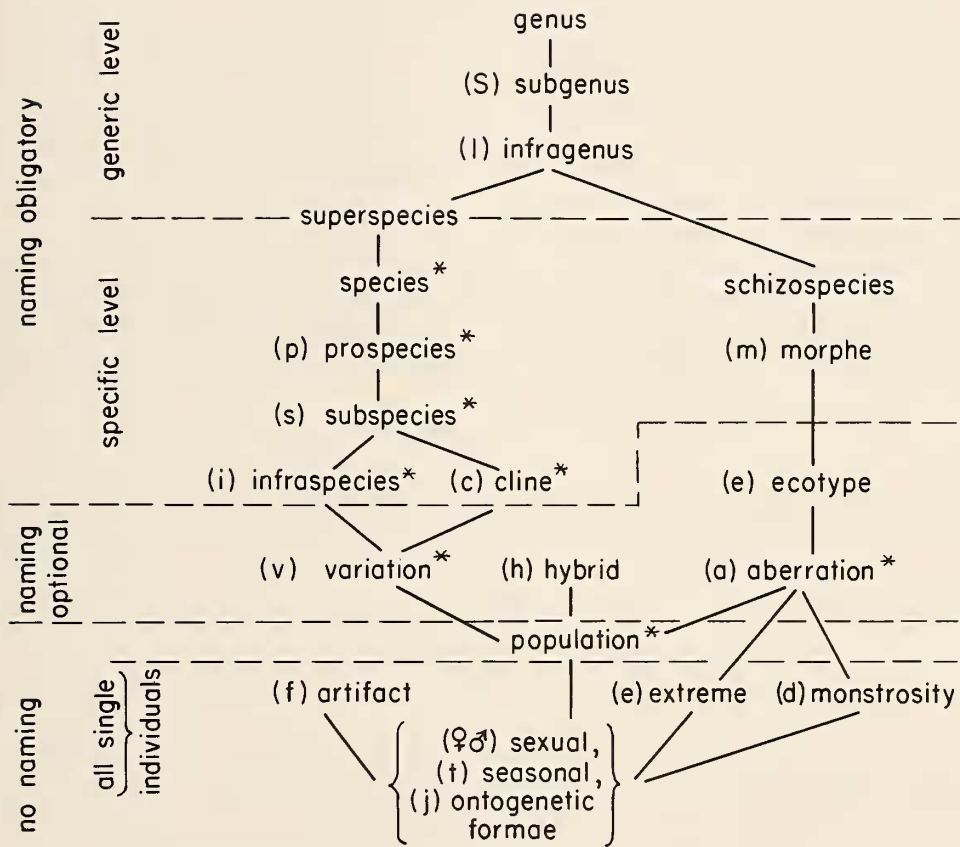
For general use I recommend the second method, while in catalogues published for showing the various steps in evolution the first method should be adopted: the bracketed letters should be indented in different ways according to the taxonomical value of each name.

In a later paper I intend to publish a complete list of living Cypraeidae which will contain all synonyms and adopt the taxa proposed in the present paper.

I think it helpful for students to review the proposed taxa in the following diagram.

LITERATURE CITED

- CATE, CRAWFORD NEILL
1960. A new subspecies of *Cypraea saulae* GASKOIN, 1843. *The Veliger* 3 (2): 34-37; pl. 5; 1 map; 1 table. (1 Oct. 1960)
- DONOHUE, JERRY
1965. *Cypraea*: a list of the species. *The Veliger* 7 (4): 219-224 (1 April 1965)
- HUXLEY, JULIAN
1939. Clines: an auxiliary method in taxonomy. *Bijdr. Dierk.* 27: 491
1955. Morphism and evolution. *Heredity* 9: 1-52
- KLEINSCHMIDT, OTTO
1926. Die Formenkreislehre und das Weltwerden des Lebens. Halle: Gebauer & Schwetschke. 188 pp., 16 pls., 50 figs.
- LINNAEUS, CAROLUS
1758. *Systema naturae*, ed. 10, vol. 1. *Holmiae.* 824 pp.
- MAYR, ERNST
1942. *Systematics and the origin of species.* New York: Columbia Univ. Press. 334 pp., 29 figs.
- RENSCH, BERNHARD
1929. Das Prinzip geographischer Rassenkreise und das Problem der Artbildung. Berlin: Borntraeger. 206 pp., 27 figs.
- SCHILDER, FRANZ ALFRED
1941. Verwandtschaft und Verbreitung der Cypraeacea. *Arch. Molluskenk.* 73 (2-3): 57-120; 2 pls.
1952. Einführung in die Biotaxonomie (Formenkreislehre). Jena: Fischer. 162 pp., 121 maps.
1960. Intraspecific taxonomy. *The Cowry* 1 (1): 8-10
1961. Zur Variabilität der Zeichnungselemente bei Porzellanschnecken (Cypraeidae). *Zool. Anzeiger* 167 (7-8): 303-309; 2 figs.
1962. Hybrids between *Cypraea tigris* LINNAEUS, 1758 and *Cypraea pantherina* SOLANDER, 1786. *The Veliger* 5 (2): 83-87, 1 diagram. (1 Oct. 1962)
1963. Lumpers and splitters. *The Veliger* 6 (2): 104-110 (1 October 1963)
1965. The geographical distribution of cowries (Mollusca: Gastropoda) *The Veliger* 7 (3): 171-183; 2 maps (1 January 1965)
1965 a. A statistical study in fossil cowries. *The Veliger* 7 (4): 236-240 (1 April 1965)
1965 b. A new variety of a rare cowry species. *Hawaiian Shell News* 13 (8): 4; 3 figs. (June 1965)
- SCHILDER, FRANZ ALFRED, & MARIA SCHILDER
1937. Revision of the genus *Monetaria* (Cypraeidae). *Proc. Zool. Soc. London for 1936*: 1113-1135; 2 pls.
1938-1939. Prodrôme of a monograph of living Cypraeidae. *Proc. Malacol. Soc. London*, 23 (3): 119-180; (1939) 23 (4): 181-231; 1 text fig.; 9 maps.
1953, 1957. Die Bänderschnecken. Eine Studie zur Evolution der Tiere. Jena: Fischer. 206 pp., 7 figs., 47 maps.
1962. Zur Kenntnis der Cypraeidae. 5. Eine neue Riesenform aus Ostafrika. *Arch. Molluskenk.* 91 (4-6): 207-212, 1 fig.



* designates allopatric taxa